

## Monitoring of sudden ionospheric disturbances (SID) from Kolkata (India)

Sandip K Chakrabarti<sup>1,2\*</sup>, K Acharya<sup>2</sup>, B Bose<sup>2</sup>, S Mandal<sup>2</sup>, A Chatterjee<sup>3</sup>,  
N M Nandi<sup>3</sup>, S Pal<sup>2</sup> and R Khan<sup>2,4</sup>

S. N. Bose National Centre for Basic Sciences, JD-Block, Salt Lake, Kolkata-700 098, India

<sup>2</sup> Centre for Space Physics, P-61 Southend Gardens, Kolkata-700 084, India

<sup>3</sup> Centre for Space Physics (Malda Branch), Raja Sarat Bose Road, Malda-732 101, India

<sup>4</sup> Bidhan Nagar High School, BD Block, Salt Lake, Kolkata-700 064, India

E-mail : chakraba@boson.bose.res.in

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**Abstract** We report our first results of monitoring sudden ionospheric disturbances (SID). We present data taken continuously for two weeks (20th September 2002 – 4th October 2002). We compare the effects of solar flares on the VLF signal with those obtained by GOES Satellite of NASA monitoring in X-rays and found excellent agreement.

**Keywords** Solar flare, ionospheres, ionospheric disturbances, radio waves (very low frequency)

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### 1. Introduction

Sudden Ionospheric Disturbances (SID) are caused by ionizing sources external to the earth, such as solar and stellar flares, gamma ray-bursts, strong X-ray flares near compact objects *etc.* By monitoring them, it is possible to locate these sources and a great deal of knowledge could be obtained about the rate at which these types of events occur in nature.

Very Low Frequency (VLF) project of the Centre for Space Physics (CSP) has been monitoring VLF activities for quite some time. During recent Leonid-2002 shower events it has detected the peak very distinctly and received signals generated by the meteors at 19KHz [1]. In this Rapid Communication, we present the result of monitoring an Indian Navy Traffic station at Vijayanarayanam which transmits the signal at 18.2 KHz. During day time, the D-layer of the ionosphere comes down and at night it goes up (making it ideal for receiving clear signals at night) [2]. We not only receive these two effects (sun-set and sun-rise) upon the signal, we also observe enhanced ionization due to solar flares. We compare some of these flares with the monitoring of solar X-ray flare by NASA/GOES satellite which

is operative at 0.5 Ang. to 8.0 Ang. The relation among the sun-rise and sun-set effects and airglow (especially Oxygen Red line at 6300 Ang.) will be presented in a separate paper. Here, we discuss only the overall behaviour and compare recent solar flare results.

### 2. Experimental setup

The loop Antenna is a Gyrator-II type and is made up of a square frame of one meter on each side and several turns of shielded single core wire is used to receive the signal. The signal is then amplified and is fed into the audio card of a Pentium-IV computer located inside the laboratory. The audio signal is sampled at 3.2 times per second. The antenna is tuned at 18.2 KHz, the frequency at which VTX3, Indian Navy traffic station at Vijayanarayanam transmits its signal. It is aligned along the south, south-west direction. The magnetic field of the VLF signal induces a current in the antenna which is then collected as an audio signal.

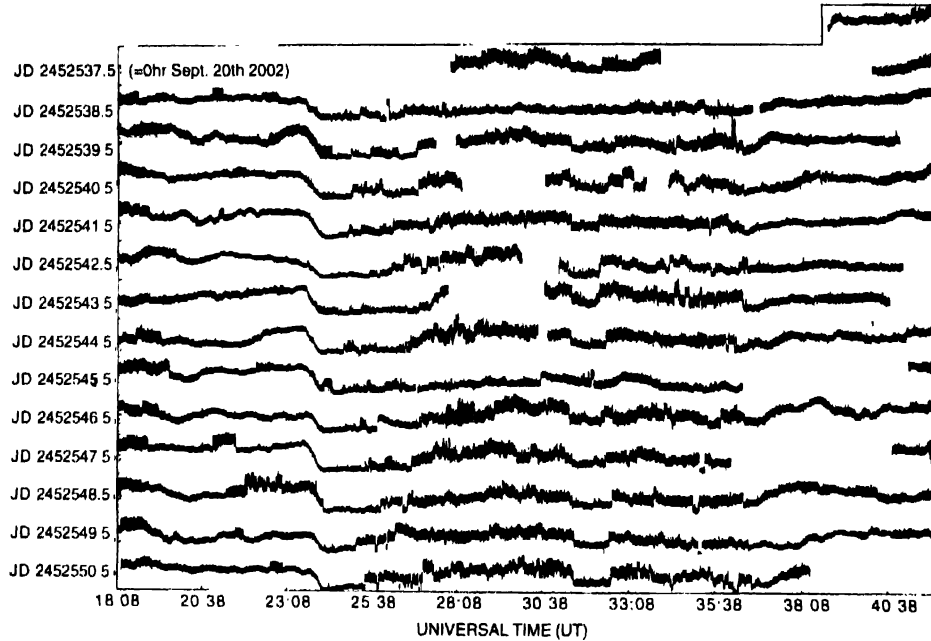
### 3. Results

Figure 1 shows the results of continuous monitoring (barring maintenance and power failure) the output from September 20th,

\*corresponding Author

2002 to October 4th, 2002. The days are given in Julian Day and times are in Universal Time (UT). At the sun rise, the signal

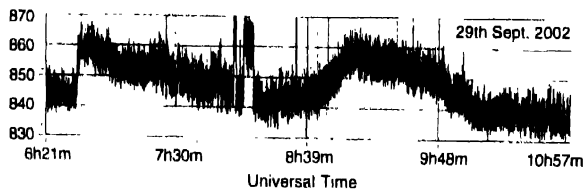
observation since the true sun-rise above the horizon is shifted. The sun-set (around 37h each day) effect is not very prominent



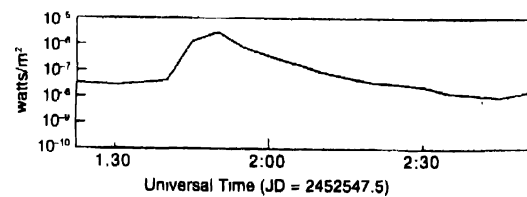
**Figure 1.** VLF signals at 18 KHz is shown for two weeks period stacked for the sake of comparison. Apart from sun-rise and sun-set effect, the effects of solar flares throughout the day are also observed. The day numbers (in Julian Day) are written beside each curve and the time is in Universal Time (UT).

drops (around 0h10m each day) in a matter of about 15 minutes as the ionization layer drops to about 40km about the earth. The sun-rise effect itself has shifted by a tens of minutes during our

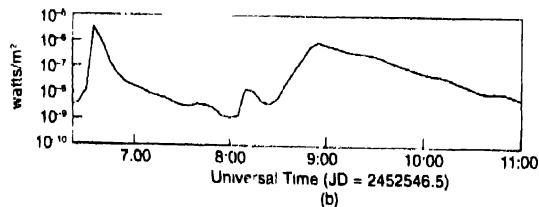
and it takes more than one hour and thirty minutes for the D-region to disappear. Some of the VLF observations from Kolkata were reported earlier at other frequencies [3, 4].



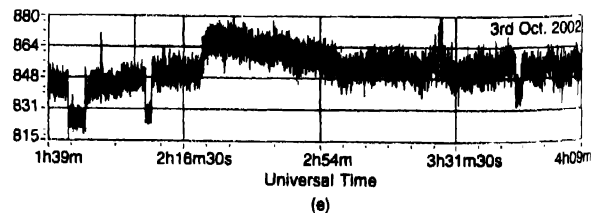
(a)



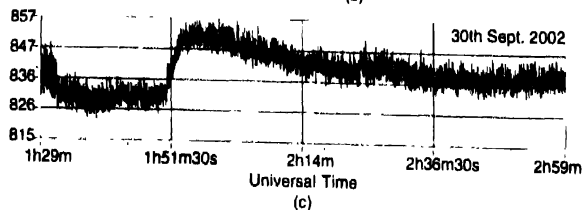
(d)



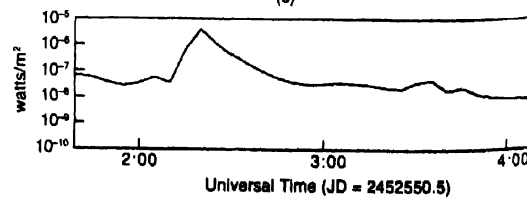
(b)



(e)



(c)



(f)

**Figure 2.** (a-f) : Comparison of the results obtained by CSP monitoring station and the results of solar flares obtained by NASA GOES satellite operating in X-rays. In (a), (c) and (e) the CSP data is presented (0.3 sec sampling rate) for flares on 29th Sept. 2002, 30th Sept. 2002 and 3rd Oct. 2002 while in (b), (d) and (f), the corresponding NASA observations (five minute average) are shown. The times are in Universal Time (UT).

In between the sun-rise and the sun-set, several events have been recorded which we identify as due to the solar flare. For illustration, we consider the pair of active flares occurring on the 29th of September, 2002 (JD 2452545.5+) in Figure 2a, one flare occurring on 30th of September, 2002 (JD 2452546.5+) in Figure 2c, and one flare occurring on 3rd of October, 2002 (JD 2452549.5+ ) in Figure 2e. For comparison we also present GOES satellite data which are integrated over five minutes obtained from NASA archive [5] (in Figures 2b, 2d and 2f). Not only the locations of the peaks match, the profiles also match within the error-bars inherent with the audio-card. The duration of the SID is about one hour or more, consistent with published reports [6] for the same class of flare. Very weak signals are masked by our receiving process and cannot be detected.

#### 4. Concluding remarks

There has been very high degree of solar activity in recent months as reported by NASA [5]. A large number of sunspots are forming and disappearing on the solar disk. Magnetic flares [2] increase the ionization and disturb the constant signal

received by our monitoring station. These Sudden Ionospheric Disturbances (SID) are being monitored at CSP monitoring stations located at Malda and Garia (South Kolkata). We reported fourteen days of such data obtained at the Kolkata station which indicated how the ionosphere is disturbed and how long it takes for the disturbance to subside. We also compared the profiles of several 'active' flares with the results obtained by NASA GOES satellite operating to detect X-ray flares on the sun. We find excellent agreements in these results, although the methodologies are completely different.

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